BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2015 HSC Chemistry Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

Question	Answer
1	B
2	D
3	B
4	C
5	A
6	B
7	B
8	C
9	C
10	A
11	D
12	A
13	B
14	D
15	A
16	C
17	D
18	A
19	C
20	D

Section I, Part B

Question 21 (a)

Criteria	Marks
• Correctly outlines all steps	2
• Identifies some steps	1

Sample answer:

- Collect some coloured plant material such as red cabbage. Select the coloured parts and cut into small pieces
- Place them in a beaker with water and boil until the water becomes coloured
- Cool mixture
- Decant the liquid into a container, leaving the solid behind.

Question 21 (b)

Criteria	Marks
• Outlines a suitable activity using a natural indicator to show the different colours in acidic and basic solutions	2
• Identifies a suitable activity for testing a natural indicator	1

Sample answer:

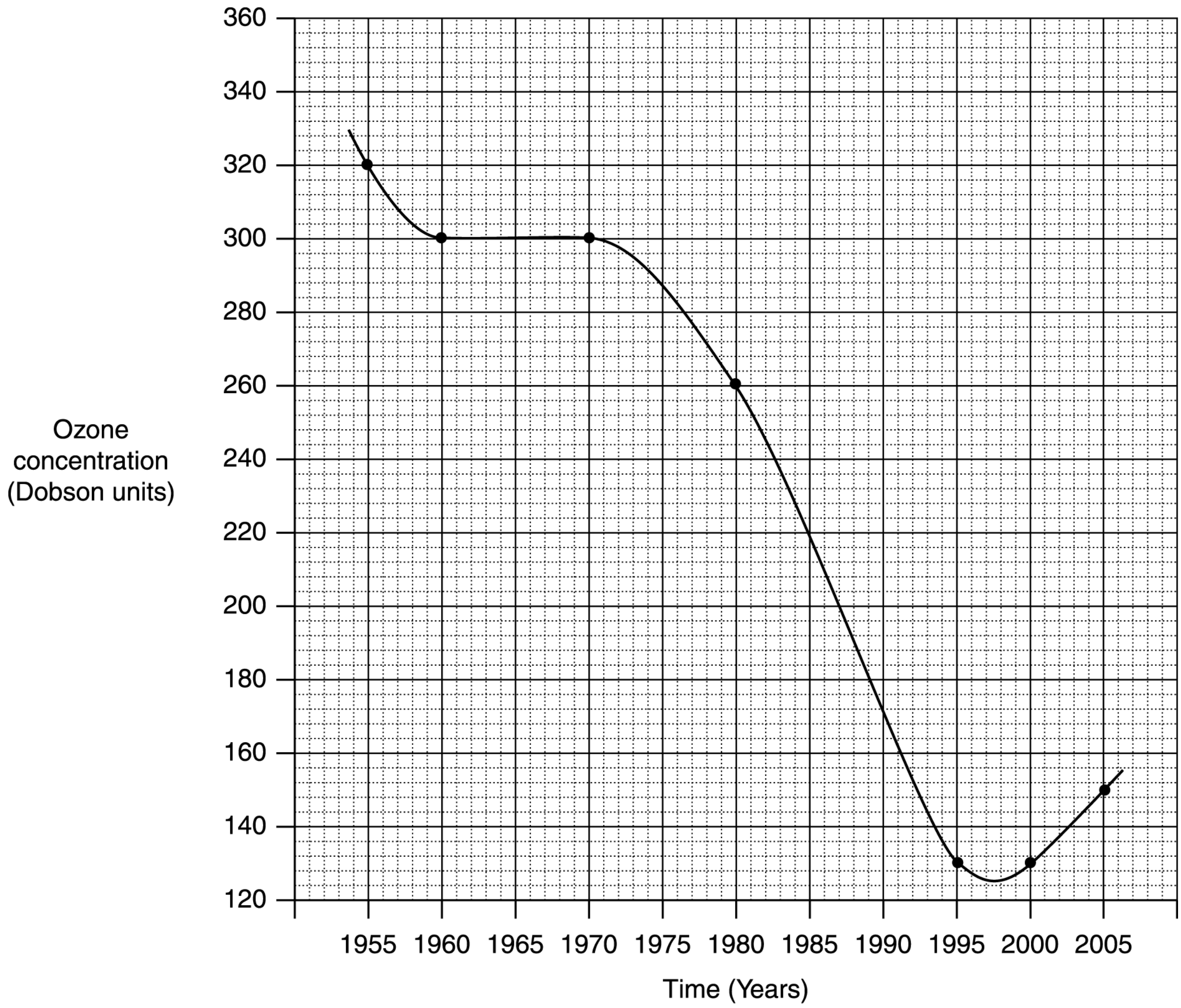
Add some of the indicator to separate test tubes of a known acid and base.

Record the natural indicator colour in the acid and base.

Question 22 (a)

Criteria	Marks
• Provides a correct graph that includes labelled axes, units, appropriate scales, plotted points and a smooth line of best fit	4
• Provides a substantially correct graph	3
• Provides a graph that includes a scale	2
• Provides some relevant information	1

Sample answer:



Question 22 (b)

Criteria	Marks
• Describes how a ground-based technique or instrument launched into the upper atmosphere can be used to measure ozone levels	3
• Outlines an instrument and/or a technique that can be used to measure ozone levels	2
• Identifies an instrument or a technique that can be used to measure ozone levels	1

Sample answer:

The information could be measured by a ground-based UV spectrophotometer. This analyses UV light intensity at a wavelength at which ozone absorbs, and compares the intensity to a nearby wavelength of UV that ozone does not absorb. The amount of absorption by ozone provides information about ozone concentrations. Similar measurements over time allow ozone concentrations to be monitored.

Question 23

Criteria	Marks
• Outlines the structure and chemistry of the cell • Relates these to its cost and practicality	4
• Outlines the structure and chemistry of the cell • Links these to its cost or practicality OR • Outlines some features of the structure and/or the chemistry of the cell • Links these to its cost and practicality	3
• Outlines some features of the cell's structure and/or its chemistry and/or its cost and/or its practicality	2
• Provides some relevant information about the cell, its cost or its practicality	1

Sample answer:

Name of cell: *Silver Button Cell*

Chemistry:

Anode: Zinc powdered
$Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$

Cathode: C/Ag_2O paste
$Ag_2O + H_2O + 2e^- \rightarrow 2Ag(s) + 2OH^-$

Electrolyte: $KOH/Zn(OH)_2$ paste

Since the cell is small in size, lightweight and has a stable voltage over a long period of time it is useful in small appliances such as cameras, calculators and watches.

Whilst silver is an expensive metal, the cell is relatively in expensive to purchase, these days.

Question 24 (a)

Criteria	Marks
• Recognises that the salt produces hydroxide ions and relates this to the formation of a basic solution • Includes a relevant equation	2
• Recognises that hydroxide ions are produced OR • Includes a relevant equation	1

Sample answer:

$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

The presence of OH^- ions produced by the hydrolysis of CH_3COO^- increases the pH of the solution and results in a basic pH.

Question 24 (b)

Criteria	Marks
• Explains how an increase in $[OH^-]$ will affect the reaction • Relates to minimal change in pH • Includes a relevant equation	3
• Provides some explanation and/or description of how the pH would be affected • Links the reaction of OH^- to the equilibrium reaction	2
• Provides some relevant information	1

Sample answer:

$CH_3COO^-(aq) + H_3O^+(aq) \rightleftharpoons CH_3COOH(aq) + H_2O(l)$

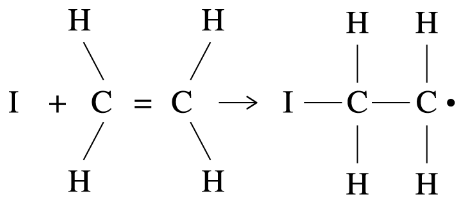
The addition of OH^- ions will cause reaction with H_3O^+ ions, reducing their concentration in the equilibrium mixture. This will force the reaction to the left to increase the $[H_3O^+]$, thus minimising the change in pH.

Question 25 (a)

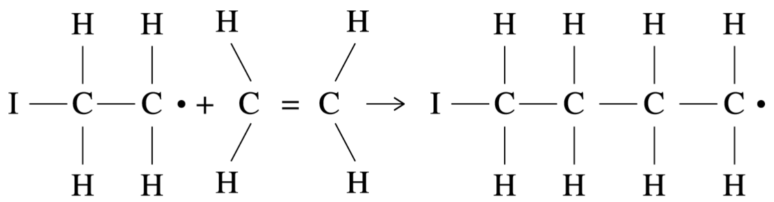
Criteria	Marks
• Includes the main features of the steps of addition polymerisation	3
• Identifies the majority of the main features of addition polymerisation	2
• Identifies ethylene as a monomer OR • Identifies a relevant step OR • Idenitifes a relevant chemical concept	1

Sample answer:

Initiator (I) (organic peroxide) attacks ethylene molecule, breaking double bond, and producing an unpaired reactive electron on the end of the growing chain (initiation).



This will attack another ethylene molecule, increasing the length of the growing chain (propagation).



Chain length continues to grow in this fashion until two growing chains combine (termination).

Question 25 (b)

Criteria	Marks
• Relates the uses of both polymers to their structures and properties	4
• Relates the uses of both polymers to their structures and/or properties	3
• Gives the structures of both polymers, and a property/use of one of the polymers OR • Gives the properties of both polymers, and a structure/use of one of the polymers OR • Gives the uses of both polymers, and a structure/property of one of the polymers	2
• Gives the structure OR a use OR a property of one of the polymers	1

Sample answer:

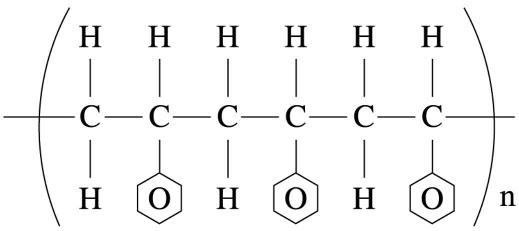
Polystyrene consists of long carbon chains with benzene rings attached along the chain.

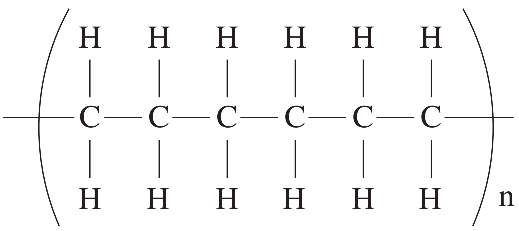
Polystyrene can be used for screwdriver handles and car battery cases because the large benzene rings create a much stiffer, more rigid structure.

Polyethylene consists of long carbon chains with no side groups.

Polyethylene is used in cling-wrap and milk bottles because the long chains are flexible.

Answers could include:

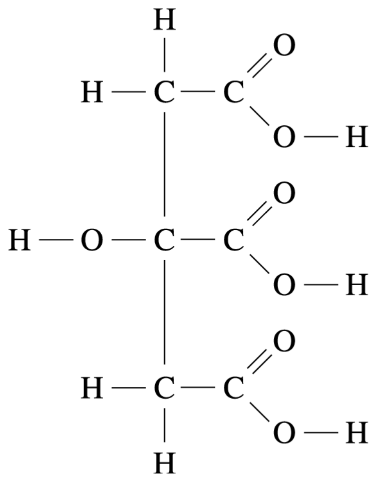




Question 26 (a)

Criteria	Marks
• Draws a correct structural formula for citric acid	1

Sample answer:



Question 26 (b)

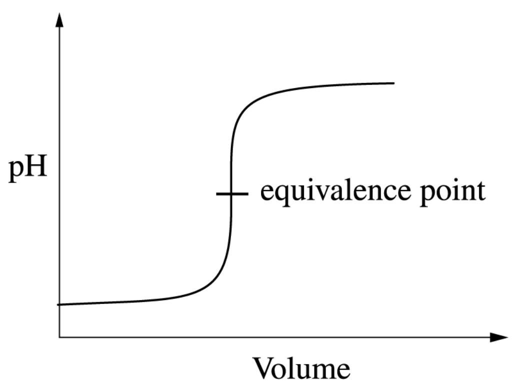
Criteria	Marks
• Outlines how a computer-based technology could be used to identify the equivalence point	2
• Provides some relevant information	1

Sample answer:

A digital pH probe was used to collect appropriate data to plot a graph of pH vs volume of sodium hydroxide.

The equivalence point was identified from the graph obtained from the data collected by the pH probe.

Answer could include:



Question 26 (c)

Criteria	Marks
• Correctly calculates the concentration of sodium hydroxide • States answer to three significant figures	4
• Correctly calculates the concentration of sodium hydroxide	3
• Applies correct steps to calculate the concentration of the sodium hydroxide solution OR • Correctly calculates moles of citric acid and moles of sodium hydroxide with correct equation	2
• Substitutes into a relevant formula OR • Provides a relevant equation OR • Shows a basic understanding of the calculation required	1

Sample answer:

$n = cV = 0.100 \times 0.0250$
Moles citric acid = 0.00250

$C_6H_8O_7 + 3NaOH \rightarrow C_6H_5O_7Na_3 + 3H_2O$

41.50 mL NaOH must contain 3×0.00250 moles
= 0.00750 moles

$$c = \frac{n}{V} = \frac{0.00750}{0.04150} = 0.18072$$

$= 0.181 \text{ mol L}^{-1}$ (3 significant figures)

Question 27

Criteria	Marks
• Names a radioisotope used in a non-medical industry • Identifies issues and provides points for and/or against its use in that industry in terms of its properties	5
• Names a radioisotope used in a non-medical industry • Outlines its use in that industry and its properties relevant to the use	4
• Names a radioisotope used in a non-medical industry • Outlines its use in that industry and at least one of its properties relevant to the use	3
• Names a radioisotope used in a non-medical industry and identifies a use or a property of the radioisotope OR • Identifies use(s) and/or property(ies) of radioisotopes used in non-medical industries	2
• Names a radioisotope OR • Identifies a use or a property of radioisotopes used in non-medical industries	1

Sample answer:

Co-60 is used in industrial radiography to inspect metals and welds for defects

Beams of radiation are passed through the object to be checked from a selected source of Co-60. More radiation will pass through where there are cracks or weaknesses.

Co-60 is used as it is a gamma-emitter and penetrates metal, providing a non-destructive, fast, accurate and relatively cheap process. It also has a relatively long half-life (5.3 years), and therefore the radioisotope does not need to be replaced on a regular basis.

One disadvantage of working with Co-60 is that it is radioactive and beams of radiation are used to detect defects. It can be dangerous when workers are exposed to it, therefore care needs to be taken to minimise the risk.

Question 28 (a)

Criteria	Marks
• Correctly shows why this would not be considered an Arrhenius acid-base reaction	1

Sample answer:

This reaction does not occur in aqueous solution.

Question 28 (b)

Criteria	Marks
• Provides a valid reason • Includes a relevant equation	2
• Provides some relevant information	1

Sample answer:

It involves proton transfer.

$HCl(g) + NH_3(g) \rightarrow NH_4^+ + Cl^-$

Question 29 (a)

Criteria	Marks
• Provides appropriate suggestions with well-linked justifications	4
• Provides appropriate suggestions and justification for at least one of the suggestions	3
• Provides appropriate suggestions OR • Provides an appropriate suggestion with justification	2
• Provides an appropriate suggestion	1

Sample answer:

Barium sulfate is a very fine precipitate. After the $BaCl_2$ was added, the mixture could be heated for some time. This allows the fine $BaSO_4$ precipitate to flocculate into larger particles, which would be trapped by the filter. The pores of most filter paper are still too large to effectively capture the $BaSO_4$ precipitate, and so filtering should be done using a sintered glass crucible, which has small pore sizes.

The sulfate will not be evenly distributed throughout the mixture, so to achieve more reliable and valid results, several samples of the fertiliser should be used so that an average value for the sulfate content in the mixture could be determined.

Question 29 (b)

Criteria	Marks
• Correctly calculates the percentage of sulfate in the original sample	3
• Provides a substantially correct response	2
• Applies a relevant step OR • Provides a relevant equation	1

Sample answer:

Calculations:

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

mass of fertiliser used: 2.00 g
mass of precipitate formed: 2.23 g

$$\text{mass of } SO_4^{2-} = \frac{\text{Molar mass of } SO_4^{2-}}{\text{Molar mass of } BaSO_4} \times 2.23 = \frac{96.07}{233.37} \times 2.23 = 0.918$$

$$\therefore \ \% \text{ of } SO_4^{2-} \text{ in the fertiliser} = \frac{0.918}{2.00} \times 100 = 45.9\%$$

Question 30

Criteria	Marks
• Relates the conditions used in the Haber process to yield and rate considerations and Le Chatelier's principle • Relates information in the graph to these conditions • Provides a logical response with no extraneous information	6
• Links conditions used in the Haber process to yield, rate and Le Chatelier's principle • Links the graph to temperature and pressure	5
• Links conditions used in the Haber process to yield/rate and Le Chatelier's principle • Refers to the graph	4
• Links conditions used in the Haber process to Le Chatelier's principle and/or yield and/or rate and/or the graph	3
• Identifies condition(s) used in the Haber process and/or yield and/or rate and/or the graph and/or feature(s) of Le Chatelier's principle	2
• Provides some relevant information	1

Sample answer:

In the Haber process, ammonia is produced from nitrogen and hydrogen in the following exothermic reaction.

$N_2(g) + 3H_2(g) \qquad 2NH_3(g) \qquad \Delta H = -92$ kJ

Being exothermic, yield is increased by lowering the temperature of the reaction mixture, which would drive the reaction to the right, as according to Le Chatelier's principle, the reaction would be favoured that produced heat. On the graph, this is clearly shown, as for each pressure, the yield increased at lower temperatures. Maximum yield could be obtained at very low temperatures, however, the rate of ammonia formation would be compromised at low temperatures, hence, in the Haber process, a temperature of about 450°C is used. This produces an acceptable yield. A catalyst of Fe_3O_4 is used to maintain an acceptable rate of reaction at this low industrial temperature. In the reaction above, there is a 4:2 ratio of gaseous reactants to products, so higher pressures will drive the reaction to the right to reduce moles of gas, which reduces the pressure. Ideally as shown on the graph, extreme pressures would increase the yield. However, in the Haber process, the cost of maintaining high-pressure reaction vessels is prohibitive, so a pressure of 300 atm is used which is an acceptable compromise.

Section II

Question 31 (a) (i)

Criteria	Marks
• Accounts for changes in concentration	2
• Outlines a change in concentration	1

Sample answer:

Initially, $[H_2]$ would drop as the volume of the container was suddenly increased. However, as there is a 3:1 ratio of gas particles in the equilibrium reaction, the reverse reaction would be favoured to increase pressure by increasing the number of particles, and so $[H_2]$ would then start to increase again until equilibrium was re-established.

Question 31 (a) (ii)

Criteria	Marks
• Correctly calculates the equilibrium constant	3
• Provides some relevant steps	2
• Applies data to a relevant calculation	1

Sample answer:

	Moles H_2	*Moles CO*	*Moles CH_3OH*
Initially	0.50	1.00	2.50
Used/made	0.36	0.18	0.18
Equilibrium	0.86	1.18	2.32

∴ equilibrium concentrations in the 2.00 L container
$[H_2] = 0.43$
$[CO] = 0.59$
$[CH_3OH] = 1.16$

$$K = \frac{[CH_3OH]}{[H_2]^2[CO]} = \frac{1.16}{0.43^2 \times 0.59} = 11$$

Question 31 (b) (i)

Criteria	Marks
• Provides a logical sequence of steps with relevant chemicals • Includes appropriate apparatus • Addresses a safety issue	3
• Provides some steps • Provides relevant chemicals and/or addresses a safety issue	2
• Includes an appropriate chemical OR • Provides a relevant step OR • Identifies a hazard OR • Includes a safety measure	1

Sample answer:

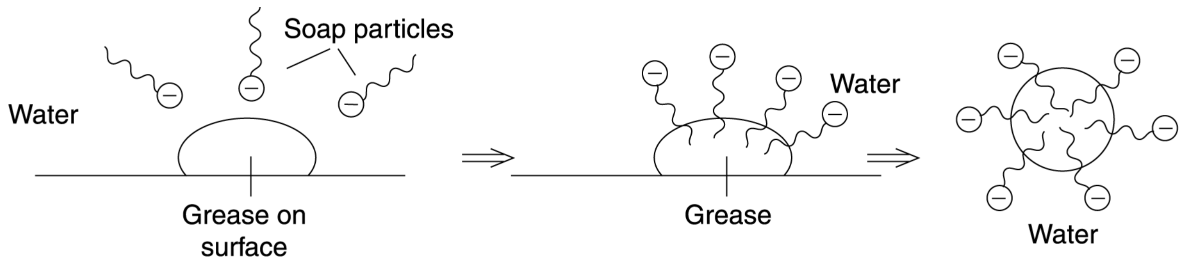
- Safety goggles used due to corrosive NaOH used in preparation
- 5 mL olive oil mixed with 5 mL ethanol and 5 mL NaOH solution in an evaporating basin
- Mixture heated over a hot water bath
- After some time, saturated NaCl solution added to precipitate the product
- Solid product scooped out with spatula, washed with water and then compressed into a small block of soap

Question 31 (b) (ii)

Criteria	Marks
• Provides an explanation of the processes linking the structure of soap to its ability to form an emulsion in water with grease	4
• Outlines the structure of soap • Outlines some emulsifying properties of soap	3
• Outlines some features of the structure and/or emulsifying properties of soap OR • Identifies the product of saponification and that an emulsion is formed	2
• Identifies the product of saponification OR • Identifies a feature of the structure of soap OR • Makes a correct statement about the cleaning properties of soap	1

Sample answer:

The product of saponification is soap. This has a non-polar hydrophobic tail and a polar, hydrophilic negatively charged head. Soap is effective at cleaning non-polar grease from surfaces. The non-polar tail dissolves in the non-polar grease.



When enough soap is dissolved in the grease, the grease is lifted from the surface. The negatively charged heads of the soap prevent the grease drops from sticking together, effectively emulsifying the grease, allowing it to be carried away from the surface.

Question 31 (c) (i)

Criteria	Marks
• Clearly outlines the chemical processes that take place in the reaction vessel and the heating process • Includes chemical equations	3
• Outlines a chemical process that takes place in the production • Includes a chemical equation	2
• Identifies a feature of a relevant chemical process	1

Sample answer:

In the reaction vessel carbonic acid forms.

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$$

Ammonia converts this to the bicarbonate ion.

$$NH_3(aq) + H_2CO_3(aq) \rightleftharpoons NH_4^+(aq) + HCO_3^-(aq)$$

At low temperatures (0°C) Na^+ from the brine causes precipitation of $NaHCO_3(s)$. This is filtered and then heated to produce $Na_2CO_3(s)$.

$$2NaHCO_3(s) \xrightarrow{\text{heat}} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

Question 31 (c) (ii)

Criteria	Marks
• Links the requirements for the location of a Solvay plant to relevant features of the diagram	3
• Outlines some requirements for the location of a Solvay plant	2
• Identifies a requirement for the location of a Solvay plant OR • Identifies a suitable location for a Solvay plant	1

Sample answer:

In the diagram, substantial inputs include brine (often sourced from sea water) and carbon dioxide (obtained from limestone). Since ammonia is recycled, location of the plant is not dependent on ammonia production. $CaCl_2$ is the substantial by-product.

It is easier to transport bulk solid limestone long distances so it is more important to locate a Solvay plant near the ocean to access brine. Limestone deposits relatively close are desirable but not critical, so long as transport of limestone is available. Locating near the ocean also allows excess $CaCl_2$ to be disposed of easily into the sea without causing problems to marine ecology.

Question 31 (d)

Criteria	Marks
• Includes correct structure and chemistry of each method • Elaborates on technical and environmental issues associated with each method to show how the methods are similar and/or different • Provides a coherent and concise response with no extraneous information	7
• Includes correct structure and chemistry of each method • Elaborates on technical and environmental issues associated with each method	6
• Provides an outline and some chemistry of each method • Outlines technical and/or environmental issues associated with each method	4–5
• Outlines some chemistry and/or technical issues(s) and/or environmental issues(s) for at least one of the methods.	2–3
• Includes some chemistry for one method OR • Names another method OR • Identifies a technical issue for one method OR • Identifies an environmental issue for one method	1

Sample answer:

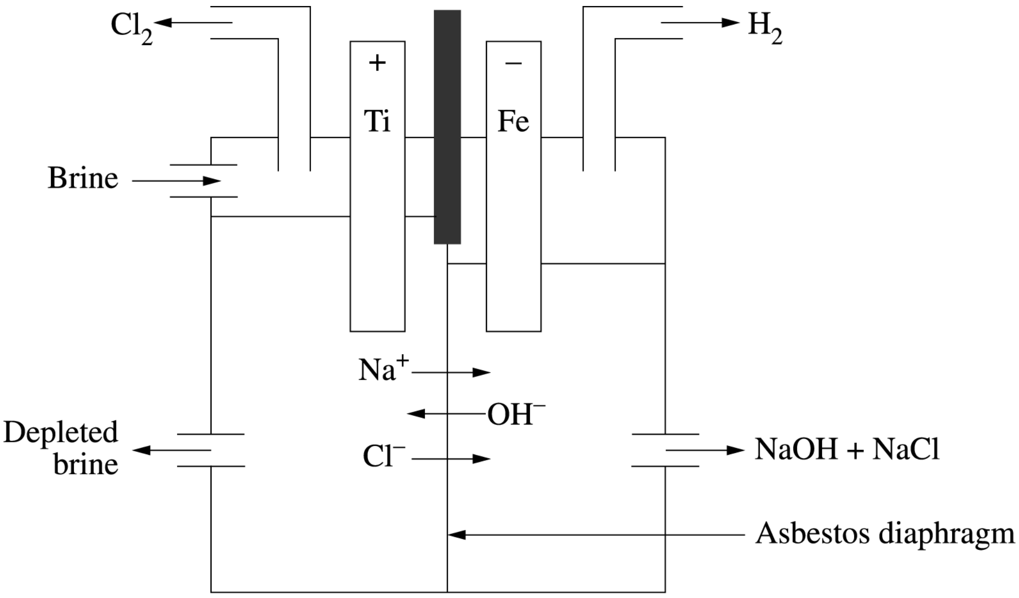
Sodium hydroxide can be produced by the membrane cell method and a similar technique known as the diaphragm cell. The chemistry involved in each of these techniques is very similar, but there are significant technical and environmental differences between them.

In the diaphragm cell, brine is placed in a half-cell with a titanium anode where Cl^- ions are oxidised to Cl_2.

$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ (oxidation)

The half-cell is separated from the cathode half-cell by a porous asbestos barrier. The iron mesh anode reduces molecules to OH^- and $H_2(g)$.

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-$ (reduction)



Problems associated with this method include the use of the asbestos diaphragm. There was the potential for workers to be exposed to carcinogenic asbestos during maintenance. In addition, migration of OH^- ions through the diaphragm produced ClO^- ions (a strong oxidising agent) into the depleted brine. This had to be removed prior to release into the environment. As well, Cl^- ions passing through the diaphragm would result in NaCl contamination in the final NaOH product.

As an alternative, the membrane cell uses identical chemistry to the diaphragm cell, but the anode and cathode compartments are separated by a semipermeable membrane produced from polytetrafluoroethylene (PTFE or Teflon). This allows positively charged sodium ions from the brine to pass through from the anode to the cathode cell to produce NaOH. However, negatively charged Cl^- and OH^- ions are repelled by the PTFE membrane. This prevents contamination of the depleted brine with hypochlorite and the contamination of NaOH with NaCl. In addition, the PTFE is harmless. Hence, the membrane cell is superior as it allows uncontaminated NaOH to be produced compared to the diaphragm method. It also prevents release of ClO^- into the depleted brine, and prevents risk of exposure of workers to asbestos.

Question 32 (a) (i)

Criteria	Marks
• Outlines relevant limitations	2
• States a relevant limitation	1

Sample answer:

Paint must be constantly reapplied to maintain the ship due to scratches and other damage and this might be very time consuming.

Question 32 (a) (ii)

Criteria	Marks
• Provides an explanation of the chemical principles of sacrificial protection • Includes relevant equations	3
• Demonstrates some understanding of sacrificial protection	2
• Provides some relevant information	1

Sample answer:

Metals that are more active than iron (Mg and Zn are commonly used) are attached to the iron in order to set up a galvanic cell. These metals are corroded away in preference to the iron and need to be regularly replaced.

For example:

The Zn is oxidised at the anode.

$Zn(s) \rightarrow Zn^{2+} + 2e^{-}$ (oxidation)

The electron flow into the iron prevents the formation of Fe^{2+} ions. The electrons produced by the oxidation of the zinc reduce any Fe^{2+} ions that form back to Fe atoms.

$Fe^{2+} + 2e^{-} \rightarrow Fe(s)$ (reduction)

Question 32 (b) (i)

Criteria	Marks
• Provides characteristics and features of a relevant, valid and reliable first-hand investigation • Identifies equipment AND reagent used	3
• Outlines a relevant, valid and/or reliable first-hand investigation • Identifies equipment and/or reagent used	2
• Identifies some steps of a relevant investigation	1

Sample answer:

1. Put a sample of iron (nail) and steel (stainless) of the same size in separate containers
2. Add a reagent such as salt water, of same concentration, to each sample so that each sample is half-submerged
3. Repeat steps 1–2 for 3 sets of samples
4. Label each container
5. Leave these samples to corrode and observe them over a few weeks

Question 32 (b) (ii)

Criteria	Marks
• Relates the properties of TWO types of steel to their percentage composition	4
• Identifies the properties and percentage compositions of two types of steel OR • Relates the properties of a type of steel to its percentage composition	3
• Identifies a property and the percentage composition of a type of steel OR • Identifies the properties or percentage compositions of two types of steel OR • Provides a relationship between property and percentage composition of steel	2
• Identifies a property or the percentage composition of a type of steel	1

Sample answer:

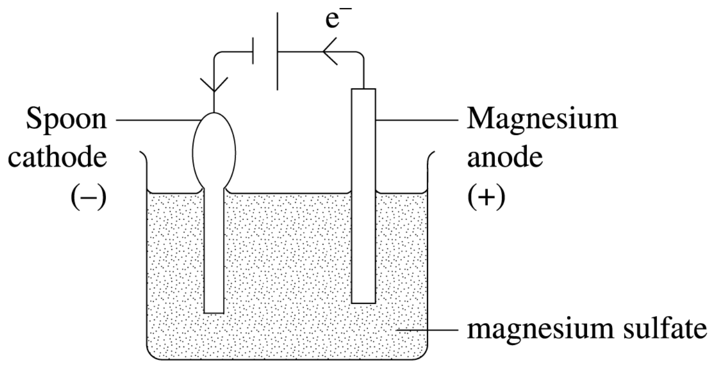
Type of steel	*Composition*	*Properties*
Mild steel	Fe and < 0.2% carbon	Soft and malleable
Structural steel	Fe and > 0.3% to 0.6% carbon	Hard, high tensile strength

The lower the carbon content of the steel the more flexible and malleable it becomes.

Question 32 (c) (i)

Criteria	Marks
• Provides a correctly labelled scientific diagram that includes the cathode, anode, direction of electron flow and polarity of the electrodes	3
• Provides a scientific diagram with at least TWO of the following correctly labelled: cathode, anode, direction of electron flow, polarity of the electrodes	2
• Provides a diagram with a cathode, anode or direction of electron flow	1

Sample answer:



Question 32 (c) (ii)

Criteria	Marks
• Clearly links Davy's work to the increased understanding of electron transfer reactions	3
• Outlines some features of Davy's work and/or electron transfer reactions	2
• Identifies a feature of Davy's work or electron transfer reactions	1

Sample answer:

Davy experimented with electrolytic cells, using much larger versions of Volta's pile, that produced much larger currents which were required to electrolyse more active metals. He discovered that active metals could be prepared by electrolysing their molten salts and that aqueous electrolytes were not the only substances that could be decomposed by electrolysis. Davy was aware that charged particles were needed to be transported for electrolysis to occur. Davy also predicted large scale use of electrolysis to make alkalis and isolating elements.

Question 32 (d)

Criteria	Marks
• Explains how the rusting processes of the two wrecks differ by considering a range of relevant factors • Includes relevant equations • Provides a coherent and concise response with no extraneous information	7
• Provides a range of relevant factors that affect the rusting of the two wrecks • Explains how the rusting processes of the two wrecks differ by considering different factors • Includes at least one relevant equation	6
• Provides relevant factors that affect the rusting of the two wrecks • Outlines the rusting processes of the two wrecks in terms of at least one of the factors • Provides at least one relevant equation	4–5
• Provides factors that affect rusting • Outlines how at least one factor affects rusting and/or provides some relevant chemistry	2–3
• Identifies a feature of the rusting process OR • Provides a relevant equation OR • Identifies a relevant difference in the two environments	1

Sample answer:

The conditions affecting rusting are

- Presence of water
- Presence of dissolved oxygen
- The pH of the electrolyte
- The temperature
- A salty environment

For sunken ships, the rate of decay and corrosion depends on the final depth of the wreck. Shallow wrecks corrode in the same way as objects on the surface, while wrecks in the deep ocean are corroded by bacterial action.

Shipwrecks in shallow water corrode as they are always wet, in contact with a good electrolyte with effective conductivity, and well aerated by wave motion allowing oxygen to dissolve.

$$\begin{array}{rl} Fe(s) \rightarrow Fe^{2+} + 2e^{-} & \text{(oxidation)} \\ O_2(g) + 2H_2O(l) \rightarrow 2Fe(OH_2)(s) & \text{(reduction)} \\ \hline 2Fe(s) + O_2(g) + 2H_2O(l) \rightarrow 2Fe(OH_2)(s) & \end{array}$$

With increasing depth of the ocean, pressure increases while temperature decreases. The solubility of gases increases with decreasing temperature and with increasing pressure. The higher the temperature, the harder it is for the gas to remain in solution. The higher the pressure, the more gas is compressed and will dissolve in water. In deep sections of the ocean, the concentration of dissolved oxygen is very low and as a result, corrosion should not occur or at least should be greatly retarded. Also the temperatures deep in the ocean are very low and corrosion reactions would proceed at a very slow rate.

Observations of deep ocean wrecks such as the Titanic show that corrosion is actually taking place. Bacteria causing corrosion on deep wrecks are sulfate-reducing species that produce acidic environments around the metals.

$$\begin{array}{rl} Fe(s) \rightarrow Fe^{2+} + 2e^{-} & \text{(oxidation)} \\ SO_4^{2-} + 8H^{+} + 6e \rightarrow S(s) + 4H_2O(l) & \text{(reduction)} \\ S(s) + 2H^{+} + 2e^{-} \rightarrow H_2S & \\ \hline 4Fe(s) + SO_4^{2-} + 10H^{+} \rightarrow 4Fe^{2+} + H_2S + 4H_2O(l) & \text{(redox)} \end{array}$$

The acidic environments produced by sulfate-reducing bacteria accelerate corrosion in non-passivating metals such as iron.

Question 33 (a) (i)

Criteria	Marks
• Correctly identifies both components with correct respiration type	2
• Correctly identifies a component OR • Correctly identifies a respiration type	1

Sample answer:

Component	*Respiration type*
Mitochondria	Oxidative decarboxylation
Cytoplasm	Glycolysis

Question 33 (a) (ii)

Criteria	Marks
• Clearly relates the biological significance of ATP to its structure	3
• Provides the function of ATP and its structure OR • Provides some link between the function of ATP and its structure	2
• Provides the structure of ATP OR • Identifies the function of ATP	1

Sample answer:

ATP has the following structure

Adenosine — P — P — P

The bonds between the phosphates provide a large amount of energy when broken to convert ATP to ADP. ATP ADP + P.

The energy released in this reaction is used to drive metabolic reactions.

Question 33 (b) (i)

Criteria	Marks
• Provides characteristics and features of a relevant, valid and reliable first-hand investigation • Identifies equipment AND reagent used	3
• Outlines a relevant valid and/or reliable first-hand investigation • Identifies equipment and/or reagent used	2
• Identifies some steps of a relevant investigation	1

Sample answer:

- Set up a range of water baths from 0°C to 100°C
- Place 1.0 mL of 3% H_2O_2 in a number of identical test tubes
- Place two test tubes in each of the water baths and allow them to reach the temperature of the water bath
- Add the same amount of crushed potato (pea size) to one test tube in each water bath. Leave other as a control
- Measure the height of the bubbles produced as a result of the action of the catalase on H_2O_2
- Repeat the procedure three times for reliability.

Question 33 (b) (ii)

Criteria	Marks
• Recognises the role of models in visualising key enzyme function at cellular level • Relates the shape of the enzyme to its specificity • Provides advantages and/or disadvantages of using models to understand how enzymes function in living systems	4
• Identifies way(s) that models can be used to understand how enzymes function • Identifies advantage(s) and/or disadvantage(s) of using models to understand how enzymes function	3
• Identifies way(s) that models can be used to understand how enzymes function OR • Identifies advantage(s) and/or disadvantage(s) of using models to understand how enzymes function	2
• Identifies a way that models can be used to understand how enzymes function OR • Identifies an advantage/disadvantage of using models to understand how enzymes function OR • Shows a basic understanding of how enzymes function	1

Sample answer:

Enzymes are catalysts, a special class of proteins that speed up cellular chemical reactions at their active sites. Use of models helps visualise the nature of these enzymes and their specificity.

Models are generally used to explain the enzyme-substrate complex that provides a low energy pathway necessary to catalyse a specific reaction.

The active site of the enzyme has a specific shape (similar to a lock) and only the correctly shaped substrate (similar to a key) will fit that site enabling bond-making and bond-breaking.

A model such as 'lock and key' is too static and does not explain the conditions which are necessary to bring the reactants together, such as collision of molecules, effect of temperature, pH and so on. It also has a fixed shape (a template) that is not true of enzymes. They have a 3D structure. However, the use of models also allows a complex biological process to be more easily understood at the molecular level.

Question 33 (c) (i)

Criteria	Marks
• Relates TWO bonding types from the diagram to the shape of the protein	3
• Provides TWO bonding types OR • Relates ONE bonding type to the shape of the protein	2
• Provides some relevant information	1

Sample answer:

As shown in the diagram there are HN and $\mathrm{C - O^{\diagup H}}$ groups on adjacent amino acids (but not neighbouring ones) that have formed hydrogen bonds between them, responsible for holding the folded pleat in place thus giving secondary structure to the protein.

The $\mathrm{— CH_2NH_3^+}$ and $\mathrm{O^- — \overset{\overset{O}{\|}}{C} — CH_2 —}$ have electrostatic forces of attraction between them thus enabling the adjacent chain to form a fold. This bond gives strength to the structure and renders shape.

Question 33 (c) (ii)

Criteria	Marks
• Outlines how changes in conditions can disrupt the intermolecular forces leading to denaturing of this protein making it biologically inactive	3
• Outlines how a change in conditions can disrupt the intermolecular forces leading to denaturing this protein	2
• Identifies ONE relevant feature of denaturisation	1

Sample answer:

Denaturing a protein such as the one shown in the diagram involves disrupting its secondary and tertiary structure thus making the protein biologically inactive.

Factors that can cause denaturing are changes in pH and temperature. The protein then coagulates into solid lumps.

Changes in pH (eg adding acid) will cause the $\mathrm{O^- — \overset{\overset{O}{\|}}{C} —}$ group to become $\mathrm{HO — \overset{\overset{O}{\|}}{C} —}$. This will destroy the electrostatic attraction between the NH_3^+ and O^-.

An increase in temperature will increase the kinetic energy, disrupting these relatively weak bonds.

Question 33 (d)

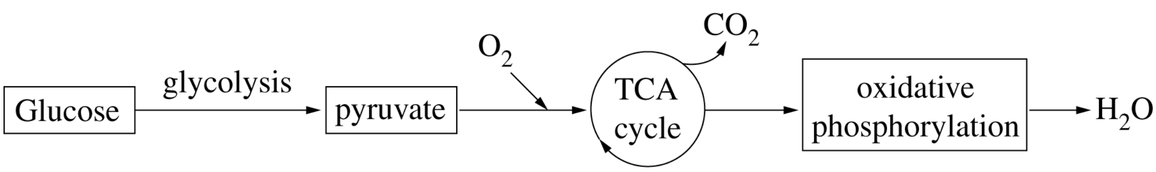
Criteria	Marks
• Shows how the metabolic pathways involved in sprinting and those involved in gentle walking are similar and/or different • Considers a range of areas such as muscle fibres, rate of ATP production, fuels used, oxygen availability and the wastes produced • Provides a coherent and concise response with no extraneous information	7
• Provides the metabolic pathways involved in sprinting and gentle walking • Compares these pathways by considering areas such as muscle fibres, rate of ATP production, fuels used, oxygen availability and the wastes produced	6
• Provides metabolic pathways involved in sprinting and gentle walking • Elaborates on areas such as muscle fibres, ATP production, fuels used, oxygen availability and waste produced in relation to these pathways	4–5
• Provides metabolic pathway(s) involved in sprinting and/or gentle walking AND/OR • Recognises the role of glucose breakdown (glycolysis)	2–3
• Identifies a feature related to sprinting or general walking	1

Sample answer:

During gentle exercise, under aerobic conditions, Type 1 muscles (slow twitch muscle fibres) are involved. They have a rich blood supply that enables them to obtain oxygen in plenty. Glucose is metabolised in glycolysis to produce pyruvate that proceeds to the TCA cycle due to plentiful supply of oxygen. This is followed by oxidative phosphorylation. The total energy output of aerobic respiration is 38 ATP.

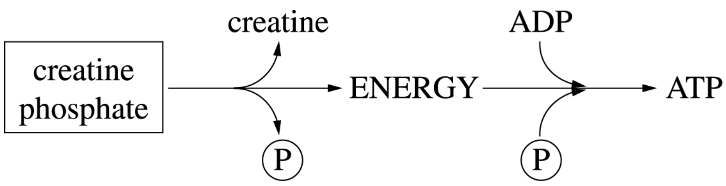
Other than glucose in the blood, amino acids and fatty acids and glycerol could also be used as fuels for aerobic respiration. Carbon dioxide and water are the waste products of glucose metabolism that are eliminated easily.

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38ATP$ (energy)

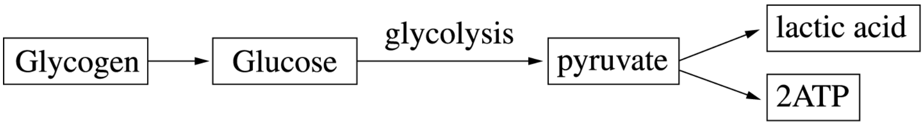


A sprinting athlete uses predominantly Type 2 muscles (fast twitch muscle fibres). These muscle fibres have a poor blood supply and as a result are deficient in oxygen. These muscles respire under anaerobic conditions when very limited or no oxygen is available. Sprinting involves intense exercise and needs large bursts of energy in a very short period of time. There are two systems that rapidly provide the energy required.

i. Phosphocreatine system (PCr) The energy release is small but at a very rapid rate. Most of the energy in a creatine phosphate molecule is in the phosphate bond. Breaking the phosphate bond releases energy that is used by the athlete in sprinting. ATP is generated in this process.

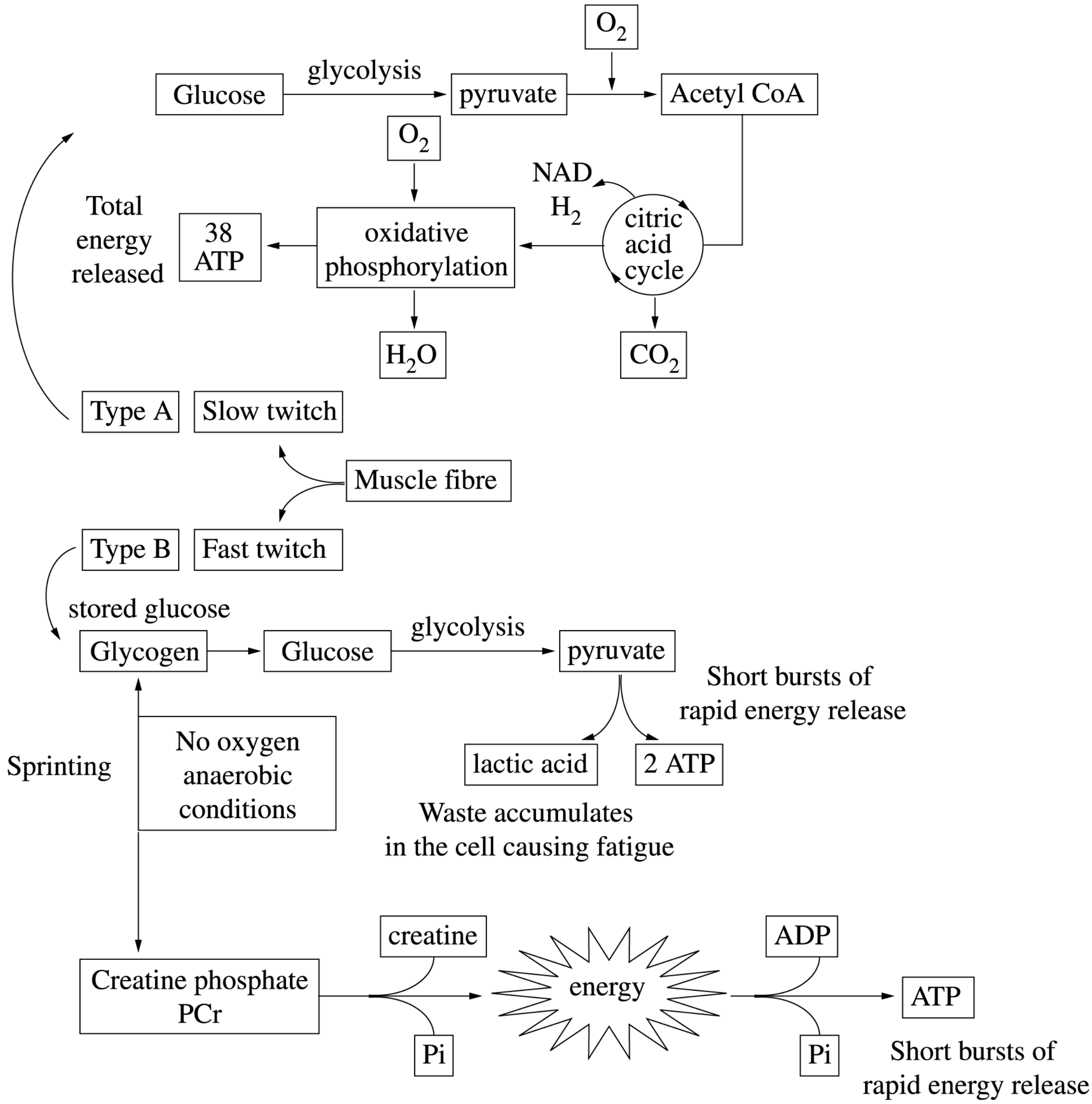


ii. <u>Anaerobic glycolysis</u> The fuel for anaerobic glycolysis comes from stored glycogen in muscle fibres. Due to low glucose concentrations in blood, glycogen is instantly converted into glucose that is then converted into pyruvate. Because of lack of oxygen, the pyruvate does not proceed to the TCA cycle, instead producing short bursts of energy plus lactic acid which accumulates in the cells as waste causing muscle fatigue.



Answers could include:

Slow walking Aerobic conditions



Question 34 (a) (i)

Criteria	Marks
• Provides the chemical composition of a cosmetic used in an ancient culture • Identifies its potential health risk	2
• Identifies a toxic component of a cosmetic OR • Identifies a health risk associated with the use of cosmetics	1

Sample answer:

Cinnabar (HgS) was used in lipstick and contains mercury. This neurotoxin is easily absorbed through the skin.

Question 34 (a) (ii)

Criteria	Marks
• Relates the colour of Cr^{2+} to its electron configuration and hence the splitting of the d orbital • Relates the lack of colour in Zn^{2+} to the lack of transition within the d orbital	3
• Relates the colour of Cr^{2+} to its electron configuration and hence the splitting of the d orbital OR • Relates the lack of colour in Zn^{2+} to the lack of transition within the d orbital	2
• Provides some relevant information	1

Sample answer:

Cr^{2+} has the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^4$. It has unpaired d subshell electrons and, when surrounded by water ligands as $Cr^{2+}(aq)$, the orbitals of its 3d subshell are split in energy. Absorption of some wavelength/s of light causes an electron/s to be excited to the higher energy orbitals and hence the solution appears coloured. In comparison, $Zn^{2+}(aq)$ is not coloured since it does not have any unpaired d subshell electrons. It has the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$.

Question 34 (b) (i)

Criteria	Marks
• Provides a detailed procedure for a safe and valid investigation, identifying the specific metal ions observed	3
• Includes the majority of the steps and the relevant metal ions that can be observed OR • Provides a detailed procedure for a relevant, safe and valid investigation	2
• Identifies a metal ion that can be identified using a flame test OR • Includes an appropriate chemical OR • Provides a relevant step OR • Identifies a hazard OR • Includes a safety measure	1

Sample answer:

- Safety glasses should be worn due to the corrosive nature of concentrated HCl
- A nichrome wire was dipped into some concentrated HCl to clean it
- The wire was then dipped into a small amount of one of the following salts: sodium nitrate, potassium nitrate, calcium nitrate, barium nitrate, copper(II) nitrate and strontium nitrate
- The nichrome wire was then placed into the hottest part of the Bunsen flame and the colour of the flame noted
- The wire was cleaned by dipping into the concentrated HCl and the process repeated until the flame colour of all salts had been observed.

Question 34 (b) (ii)

Criteria	Marks
• Provides an explanation showing clear relationship between cause and effect • Names one metal that cannot be identified using flame tests	4
• Provides an explanation showing some link between cause and effect, without naming one metal that cannot be identified using flame tests OR • Names one metal that cannot be identified using flame tests and provides some reasons why only certain metal ions can be identified using flame colours	3
• Names one metal that cannot be identified using flame tests and identifies a reason why only certain metal ions can be identified using flame colours OR • Identifies reasons why only certain metal ions can be identified using flame colours	2
• Provides some relevant information	1

Sample answer:

Flame colours are produced by the movement of electrons in the metal ions found in the compound. When the metal ion is heated, the electrons gain energy and jump to an orbital at a higher energy level. Because the electrons are now at a higher and more energetically unstable level, they fall back down to their original energy level, emitting electromagnetic radiation, often seen as light of a certain wavelength. Not all metal ions can be detected using flame tests, as electrons in certain metals, in returning to their original energy level, emit wavelengths which are not detectable by the human eye because they may be emitted in the ultraviolet and infrared regions of the electromagnetic spectrum. Aluminium is one such metal ion that releases wavelengths of energy outside the range visible to humans.

Answers could include:

Relationship between

- heating a metal ion and the movement of electrons to higher energy levels
- the return of electrons to their ground state and the emission of energy
- wavelengths emitted and visibility

Question 34 (c) (i)

Criteria	Marks
• Identifies the reduced IE for Al and S • Relates the lower first IE for Al and S to Hund's rule and the existence of orbitals	3
• Recognises some trend in IE across Period 3 of the Periodic Table and/or identifies the reduced IE for Al and S OR • Links the lower first IE for Al and S to Hund's rule and/or the existence of orbitals	2
• Recognises some trend in IE across Period 3 of the Periodic Table OR • Identifies the reduced IE for Al and S OR • Shows a basic understanding of Hund's rule or the existence of orbitals	1

Sample answer:

In general, first IE increases across the third period. However, Al has a lower 1st IE compared to Mg. In Mg, the two valence electrons are both in the s-subshell. In Al, the third valence electron is in a p-subshell, which is at a higher energy than the s-subshells, hence, less energy is required to remove the outermost electron in Al than in Mg. Phosphorous has 5 valence electrons, with two in the s-subshell and one in each of 3 p-subshells, according to Hund's rule. Sulfur has 6 valence electrons, requiring one of the p-subshells to have two electrons in it. Electrostatic repulsion between these two electrons results in less energy required to remove a valence electron, reducing the 1st IE of S compared to P.

Question 34 (c) (ii)

Criteria	Marks
• Uses the graph to identify the trends in electronegativity both down a group and across a period • Relates changes in electronegativity to the arrangement of electrons	3
• Identifies the trend(s) in electronegativity down a group and/or across a period AND/OR • Links changes in electronegativity to the arrangement of electrons in atoms	2
• Shows a basic understanding of electronegativity OR • Identifies the trend in electronegativity down a group or across a period OR • Recognises a link between electronegativity and the arrangement of electrons	1

Sample answer:

Electronegativity is a measure of the tendency of an atom to attract electrons to itself. As can be seen from the graph, electronegativity increases across a period from left to right and decreases down a group. Usually, the inert gases are not considered, because they do not usually form bonds and hence F is the most electronegative element. Electronegativity increases across a period due to an increase in nuclear charge, attracting bonding electrons more strongly. Although there is also an additional electron added with each element, this does not fully shield the effect of the increased number of protons. Electronegativity decreases down a group, because, with the addition of an extra electron shell, the size of the atom increases, the bonding pair of electrons is increasingly distant from the nucleus and the attractive force of the shielded nucleus is diminished.

Question 34 (d)

Criteria	Marks
• Provides the relevant features of the Bohr model of the atom • Provides strengths and weaknesses of the model in understanding the atomic structure and makes an informed judgement implicitly/explicitly • Makes reference to emission spectra • Provides a coherent and concise response with no extraneous information	7
• Provides the relevant features of the Bohr model of the atom • Provides strengths and/or weaknesses of the model in understanding the atomic structure and makes an implicit/explicit judgement	6
• Provides some features of the Bohr model of the atom • Provides strength(s) and/or weakness(es) of the Bohr model in understanding the atomic structure	4–5
• Provides some features of the Bohr model of the atom and/or atomic structure and/or emission spectra	2–3
• Identifies a feature of the Bohr model of the atom or the atomic structure	1

Sample answer:

Bohr proposed the ‘shell’ model of the atom, in which he envisaged electrons moving around the nucleus in orbits of fixed size and energy. Part of the reason why Bohr developed this model was to answer some of the unsatisfactory aspects of the Rutherford “planetary” model, which could not explain how charged particles could move in a circular path, emitting electromagnetic radiation and yet not spiral into the nucleus.

Bohr’s model accounts for the fact that atoms emit or absorb energy when electrons change energy levels within the atom. This explained the observation that excited atoms generate line emission spectra, when the electrons jump to a higher energy level and then return to their original level; the energy difference being released as a specific frequency of electromagnetic radiation. For the hydrogen spectrum, this model worked well. However, attempts to extend the Bohr model to atoms containing more than one electron, including helium with a more complex structure, gave results which did not agree with the line spectrum wavelengths observed. Although the model was useful in explaining some of the lines for the helium spectrum, it was too simplistic to explain them all. The model could also not explain that upon detailed analysis of the hydrogen spectrum, a single emission line was actually composed of two or more closely spaced lines. Moreover, it could not explain the Zeeman effect – changes in spectral lines due to external magnetic fields.

Certainly, there are several fundamental weaknesses associated with the Bohr model. However, it did contribute to our knowledge of atomic structure and has since had a number of enhancements made to it in the development of the Bohr-Sommerfeld model.

Question 35 (a) (i)

Criteria	Marks
• Shows how the compositions of glycogen and cellulose are similar and/or different	2
• Identifies a feature of glycogen's or cellulose's composition	1

Sample answer:

Both polymers are made of glucose monomers. Glycogen is made of α-glucose, cellulose is made of β-glucose.

Question 35 (a) (ii)

Criteria	Marks
• Correctly relates glycogen's composition to its structure • Correctly relates cellulose's composition to its structure	3
• Links glycogen's composition to its structure OR • Links cellulose's composition to its structure OR • Identifies features of glycogen's and cellulose's structures	2
• Identifies a feature of glucogen's or cellulose's structure	1

Sample answer:

Glycogen – due to α linkages forms branching side chains so it cannot align closely together and so forms a network.

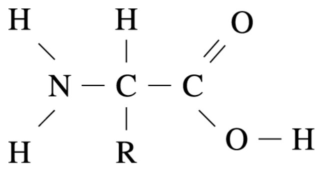
Cellulose – due to β linkages forms linear, unbranched molecules, which align closely together forming hydrogen bonds between chains making it strong and rigid.

Question 35 (b) (i)

Criteria	Marks
• Identifies the structure of amino acids • Describes the relationship between amino acids and proteins	3
• Identifies features of the structure of amino acids and/or the relationship between amino acids and proteins	2
• Identifies a feature of the structure of amino acids OR • Identifies a feature of the relationship between amino acids and proteins	1

Sample answer:

Amino acids consist of a central carbon to which is attached a carboxyl group, an amine group, a hydrogen atom and a variable side chain.



Amino acid monomers join together by peptide bonds to form long polypetide chains. The final 3D structure of the functional protein depends on the nature of the amino acid side chains.

Question 35 (b) (ii)

Criteria	Marks
• Correctly describes a procedure that: – shows the presence of protein including results – addresses validity – outlines how a risk is minimised	4
• Describes a substantially correct procedure that: – identifies the presence of protein including results – addresses validity and risk	3
• Outlines a procedure that identifies the presence of protein, addresses validity, identifies a risk or includes some expected results	2
• Provides some relevant information	1

Sample answer:

1. Take two test tubes and add 1 mL egg white to one and 1 mL of water to the other.
2. Add 10 drops of Biuret reagent A (2.0 mol L^{-1} NaOH) to each sample.
3. Then add 10 drops of Biuret reagent B (0.10 mol L^{-1} $CuSO_4$) to each sample.
4. Agitate and warm gently.
5. The test tube containing water (the control) remains pale blue, the test tube containing protein becomes purple/violet in colour.

Safety glasses must be worn as Biuret reagent A (NaOH) is corrosive.

Question 35 (c) (i)

Criteria	Marks
• Identifies the relationships of the children A, B and C to George and Linda with appropriate justification	3
• Identifies the relationships of the children A, B and C to George and Linda OR • Identifies some relationships with some justification	2
• Provides some relevant information	1

Sample answer:

The parents of child A are George and Linda because A's bands match both George and Linda's bands.
George must be a parent of child B because some of B's bands match George's bands but none of them match Linda's.
Linda must be a parent of Child C because some of C's bands match Linda's bands but none of them match George's.

Question 35 (c) (ii)

Criteria	Marks
• Provides a description of the benefits of maintaining DNA data banks	3
• Outlines some benefits of maintaining DNA data banks OR • Describes a benefit of maintaining DNA data banks	2
• Identifies a feature or a benefit of DNA data banks	1

Sample answer:

DNA data banks collect and store DNA profiles (fingerprints) from many individuals mostly from volunteers or convicted criminals. They contain very sensitive and accurate information and allow identification of individuals very precisely (1 in 6 billion). They can allow fast and accurate identification of perpetrators. They can quickly and definitively prove somebody innocent of a crime such as rape if no DNA match.

Question 35 (d)

Criteria	Marks
• Names ONE chromatography technique • Provides the relevant features of the technique • Provides strengths and weaknesses of its use in the analysis of forensic evidence and makes an informed judgement implicitly/explicitly • Provides a coherent and concise response with no extraneous information	7
• Names ONE chromatography technique • Provides the relevant features of the technique • Provides strengths and/or weaknesses of its use in the analysis of forensic evidence and makes an implicit/explicit judgement	6
• Names ONE chromatography technique • Provides some features of the technique • Provides strengths and/or weaknesses of its use in the analysis of forensic evidence	4–5
• Provides some features of chromatography techniques in the analysis of forensic evidence	2–3
• Provides some relevant information	1

Sample answer:

GLC – Gas Liquid Chromatography

This type of chromatography separates substances on the basis of their different distributions between two phases. These are either a stationary phase (usually a porous solid) and a mobile phase, which is usually an inert gas, that passes over the stationary phase. The stationary phase is packed into a column which can be 1–10 m long. The column is housed inside an oven and the temperature of the oven is set to be above the boiling points of the components of the mixture. The sample is injected into the mobile phase which carries the vapours into and through the column. As the vapours make contact with the stationary phase, some components condense more readily than others. As the mobile phase moves over the condensed components, some evaporate and are carried out of the column to a detector. Each individual component has its own unique retention time.

GLC is a very sensitive technique that can measure quantities in ppb range. The analysis can be done very quickly so that results are quickly generated. It can also be used to analyse blood and urine samples to detect illegal drugs and alcohol. It is quicker and cheaper than many other techniques and produces detailed and precise measurements from very small amounts of material. If GLC is coupled to a mass spectrometer the analysis can identify components accurately and is highly reliable for court evidence. Thus GLC is an extremely accurate and reliable method of analysing forensic evidence.

2015 HSC Chemistry Mapping Grid

Section I
Part A

Question	Marks	Content	Syllabus outcomes
1	1	9.4.4.2.1; 9.4.4.2.2; 9.4.4.2.3	H6
2	1	9.3.4.3.2; 9.3.4.2.8	H6
3	1	9.4.3.3.1	H6
4	1	9.2.4.2.3	H6
5	1	9.3.2.2.2	H6
6	1	9.4.4.2.10	H9
7	1	9.2.4.2.4	H6
8	1	9.2.3.2.3	H9
9	1	9.3.5.2.4	H9
10	1	9.2.1.3.1; 9.4.1.2.3	H9
11	1	9.2.2.2.3	H9
12	1	9.2.5.2.1	H6
13	1	9.3.3.2.5; 9.3.3.2.6; 9.3.3.2.7	H6; H12.4 (b);
14	1	9.3.4.3.3	H6; H11.3 (a); H14.1 (a)
15	1	9.4.5.2.1; 9.4.5.2.2	H6; H14.1 (a)
16	1	9.3.2.2.3; 9.3.2.2.4	H7; H8; H10
17	1	9.2.3.3.4; 9.2.2.9	H6; H9; H10; H12.4 (b)
18	1	9.4.5.3.3	H12.1 (a); H12.4 (e)
19	1	9.4.5.3.1; 9.4.5.3.2	H10; H12.4 (b)
20	1	9.2.3.2.7	H9; H12.4 (b); H14.1 (a)

Section I
Part B

Question	Marks	Content	Syllabus outcomes
21 (a)	2	9.3.1.3.1, H11.2 (c)	H11
21 (b)	2	9.3.1.3.1, H11.2 (c)	H11
22 (a)	4	9.4.4.2.11	H13.1 (f); H13.1 (g)
22 (b)	3	9.4.4.3.1; 9.4.4.2.1; 9.4.4.2.11	H3; H4
23	4	9.2.4.3.3	H3; H4
24 (a)	2	9.3.4.2.4	H6; H8; H13.1 (d); H14.1 (g)
24 (b)	3	9.3.4.2.9	H6; H8; H13.1 (d); H14.1 (g)
25 (a)	3	9.2.1.2.3; 9.2.1.2.4; 9.2.1.2.5; 9.2.1.2.6	H9
25 (b)	4	9.2.1.2.8	H3; H9
26 (a)	1	9.3.3.2.2	H9; H13.1 (d)
26 (b)	2	9.3.4.3.4	H9; H11.3 (c); H12.2 (a)
26 (c)	4	9.3.4.3.3	H10; H12.4 (b)

Question	Marks	Content	Syllabus outcomes
27	5	9.2.5.2.5; 9.2.5.2.6; 9.2.5.3.2	H1; H3; H4
28 (a)	1	9.3.4.2.1	H8
28 (b)	2	9.3.4.2.2	H8; H13.1 (d)
29 (a)	4	9.4.3.3.4	H8; H10; H12.4 (e)
29 (b)	3	9.4.3.3.3	H8; H10; H12.4 (b)
30	6	9.4.2.2.2; 9.4.2.2.3; 9.4.2.2.4; 9.4.2.2.5; 9.4.2.2.6; 9.4.2.2.7; 9.4.2.2.8; 9.4.2.2.9; 9.4.2.2.10	H7; H8; H10

Section II

Question	Marks	Content	Syllabus outcomes
Question 31		**Industrial Chemistry**	
31 (a) (i)	2	9.5.2.2.1	H6; H10
31 (a) (ii)	3	9.5.2.2.2; 9.5.2.3.3	H6; H8; H10; H12.4 (b)
31 (b) (i)	3	9.5.5.3.1; 9.5.5.2.1	H6: H9; H11.3 a); H12.1 (a); H12.2 (b)
31 (b) (ii)	4	9.5.5.2.3; 9.5.5.2.4	H6; H9;
31 (c) (i)	3	9.5.6.2.3	H6; H7
31 (c) (ii)	3	9.5.6.2.1; 9.5.6.3.3	H6; H7
31 (d)	7	9.5.4.2.2; 9.5.4.2.3	H6: H7: H8
Question 32		**Shipwrecks, Corrosion and Conservation**	
32 (a) (i)	2	9.6.4.3.3, 9.6.4.3.4	H10
32 (a) (ii)	3	9.6.4.2.4, 9.6.4.3.4	H10
32 (b) (i)	3	9.6.2.3.1	H6; H11.3 (a); H12.1 (a); H12.2 (b)
32 (b) (ii)	4	9.6.2.2.3	H6; H8
32 (c) (i)	3	9.6.1.3.1	H6; H8; H13.1 (e)
32 (c) (ii)	3	9.6.1.2.4	H1; H2
32 (d)	7	9.6.5.2.1; 9.6.5.2.3; 9.6.5.2.3; 9.6.6.2.1; 9.9.6.2.2; 9.6.5.3.1; 9.6.5.3.2	H6; H7; H8
Question 33		**The Biochemistry of movement**	
33 (a) (i)	2	9.7.5.2.1	H1
33 (a) (ii)	3	9.7.1.2.2	H2
33 (b) (i)	3	9.7.4.3.2	H4
33 (b) (ii)	4	9.7.4.3.3	H2
33 (c) (i)	3	9.7.4.2.5	H1, H6
33 (c) (ii)	3	9.7.4.2.6	H1, H6
33 (d)	7	9.7.8.3, 9.7.10.2.1, 9.7.10.3.1	H7, H8, H9
Question 34		**The Chemistry of Art**	
34 (a) (i)	2	9.8.1.3.2; 9.8.1.3.3	H6
34 (a) (ii)	3	9.8.4.2.3; 9.8.4.2.4; 9.8.5.3.2	H6

Question	Marks	Content	Syllabus outcomes
34 (b) (i)	3	9.8.2.2.1; 9.8.2.3.1	H6; H11.3 (a); H12.1 (a); H12.2 (b)
34 (b) (ii)	4	9.8.2.2.2; 9.8.2.2.3	H6; H11.2 (d)
34 (c) (i)	3	9.8.3.3.1	H6; H14.1 (a); H14.1 (f)
34 (c) (ii)	3	9.8.3.2.7	H6; H14.1 (a); H14.1 (f)
34 (d)	7	9.8.2.3.4; 9.8.2.2.5	H1; H2; H6; H7
Question 35		**Forensic Chemistry**	
35 (a) (i)	2	9.9.2.2.2	H9
35 (a) (ii)	3	9.9.2.2.4	H9; H14.3 (d)
35 (b) (i)	3	9.9.3.2.2; 9.9.3.2.3	H9; H14.3 (d)
35 (b) (ii)	4	9.9.3.3.2	H12.1 (b); H12.1 (d); H12.2 (b)
35 (c) (i)	3	9.9.4.2.2; 9.9.4.2.3	H4; H14.2 (c)
35 (c) (ii)	3	9.9.4.3.1	H4
35 (d)	7	9.9.3.2.5; 9.9.5.2.2; 9.9.5.3.1	H3; H11.3 (c)